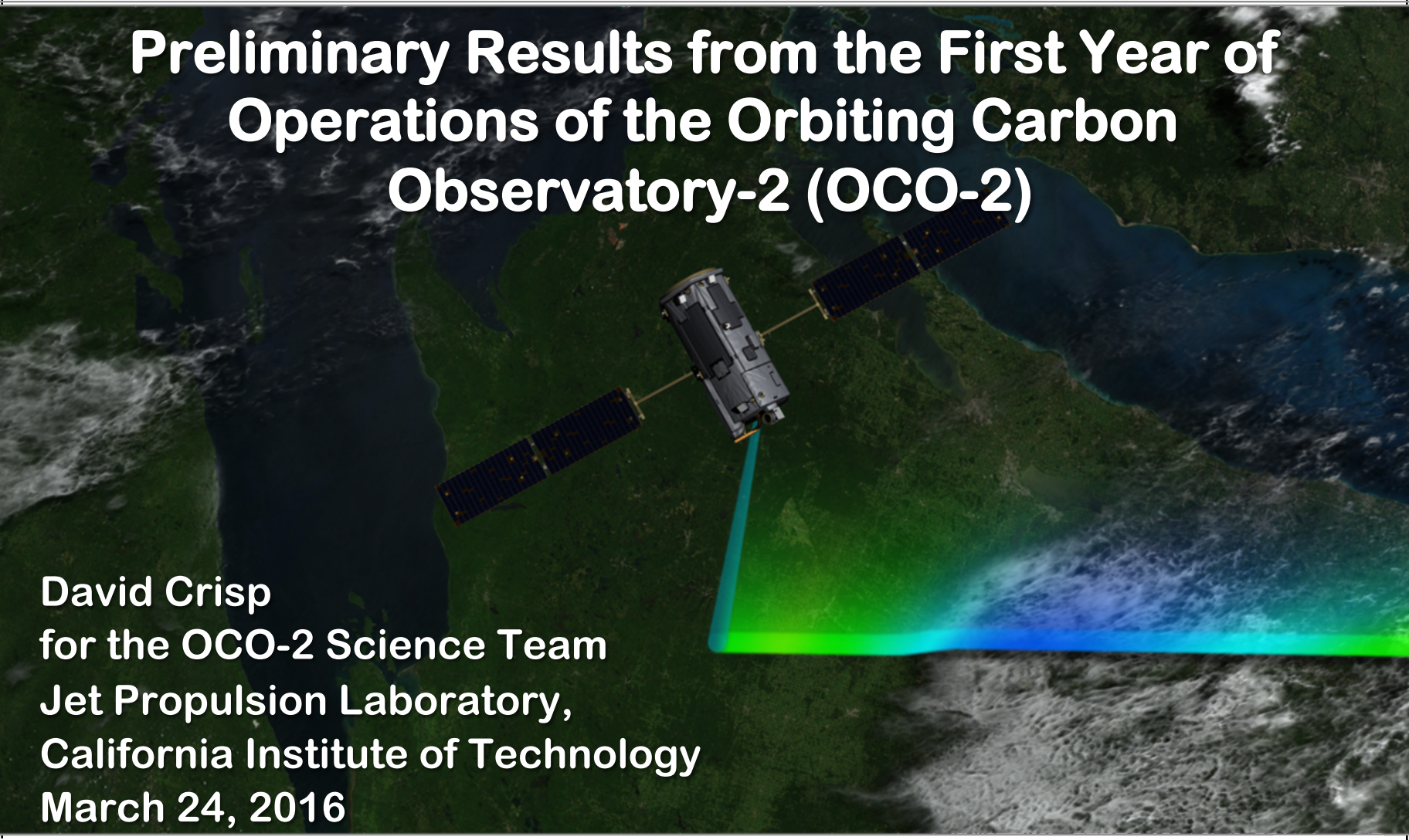
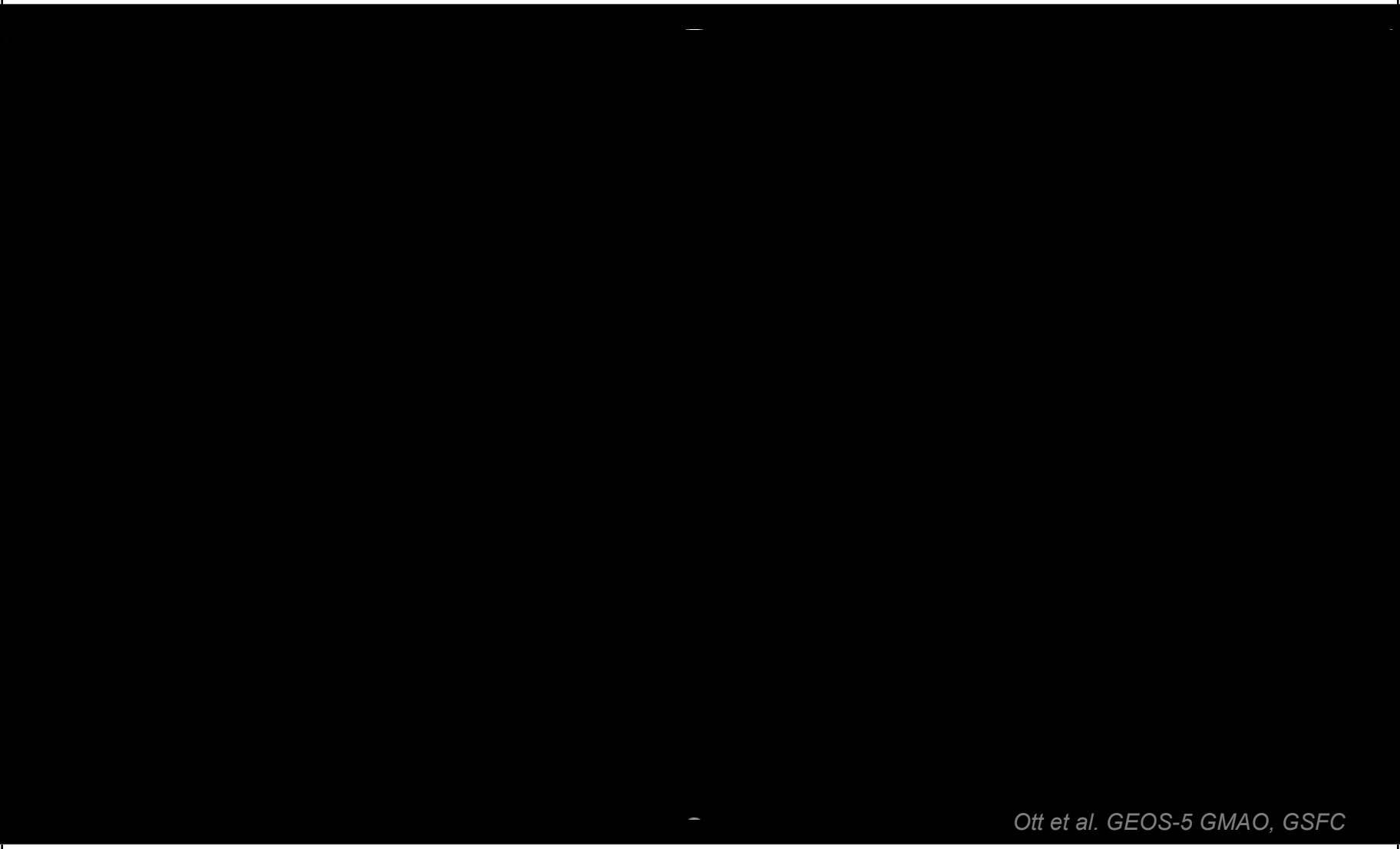
Preliminary Results from the First Year of Operations of the Orbiting Carbon Observatory-2 (OCO-2)



David Crisp
for the OCO-2 Science Team
Jet Propulsion Laboratory,
California Institute of Technology
March 24, 2016

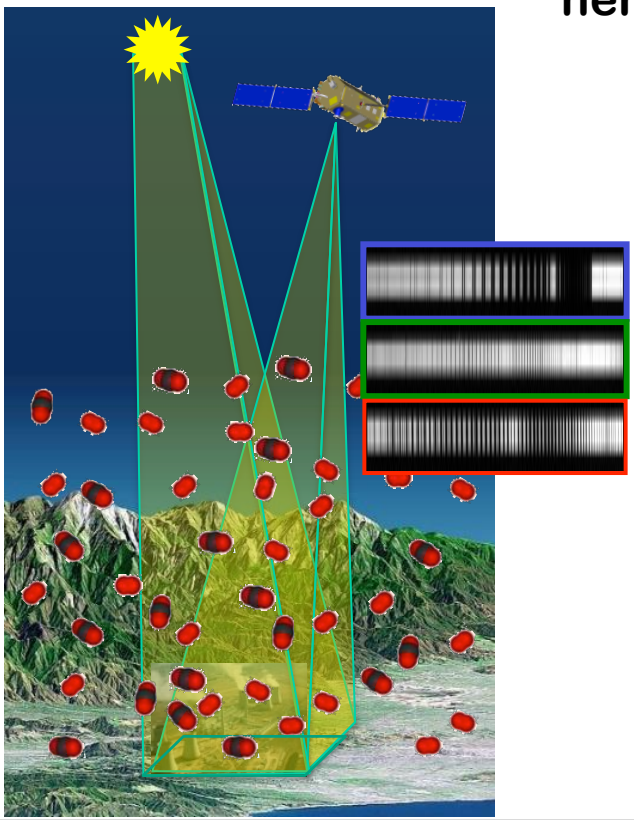
Finding the Missing CO_2 Sink



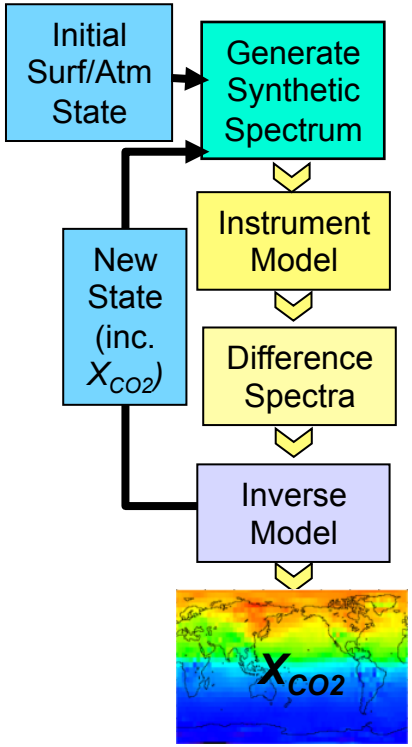
Ott et al. GEOS-5 GMAO, GSFC

Solar Near IR Observations of CO_2 from Space

- **Record** spectra of CO_2 and O_2 absorption in reflected sunlight



Retrieve variations in the *column averaged CO_2 dry air mole fraction, X_{CO2}* over the sunlit hemisphere



Validate measurements to ensure X_{CO2} accuracy of 1 ppm (0.25%)

A Perfect Launch

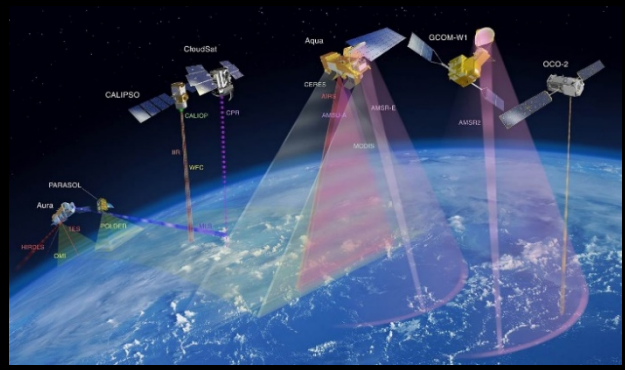
Credit: Bill Ingalls, NASA

Lift-off at 2:56 am PDT, 02 July 2014

Credit: Jeff Sullivan

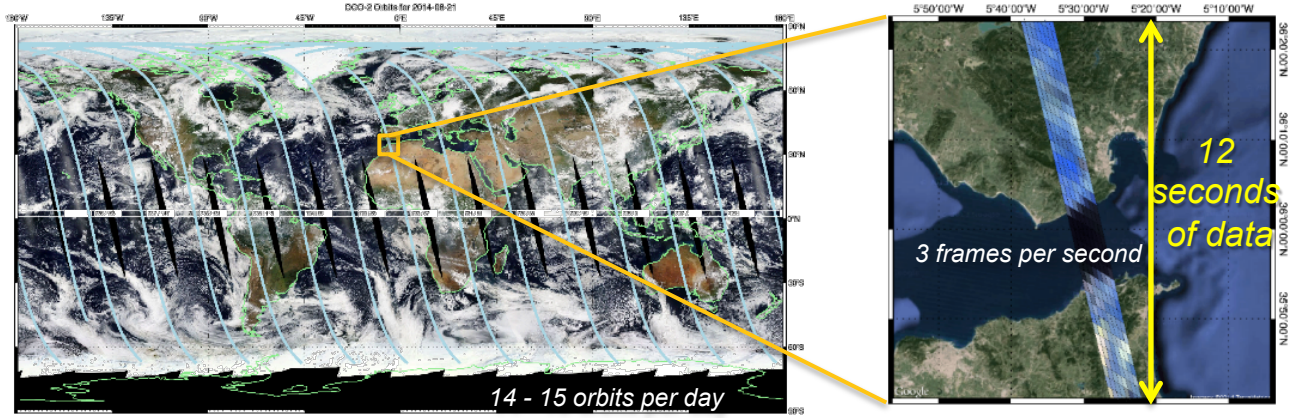
Credit: NASA

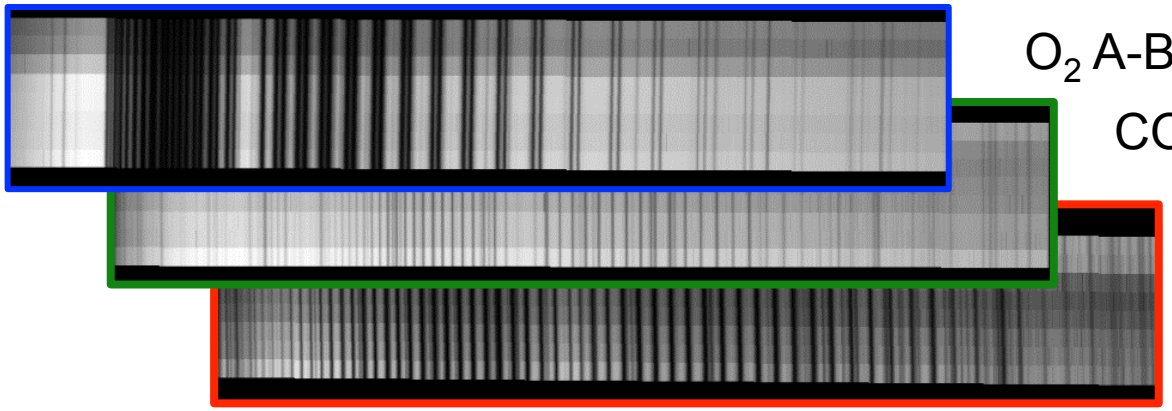
Credit: Jeff Sullivan



Joining the A-Train
3 August 2014

OCO-2 Sampling Approach





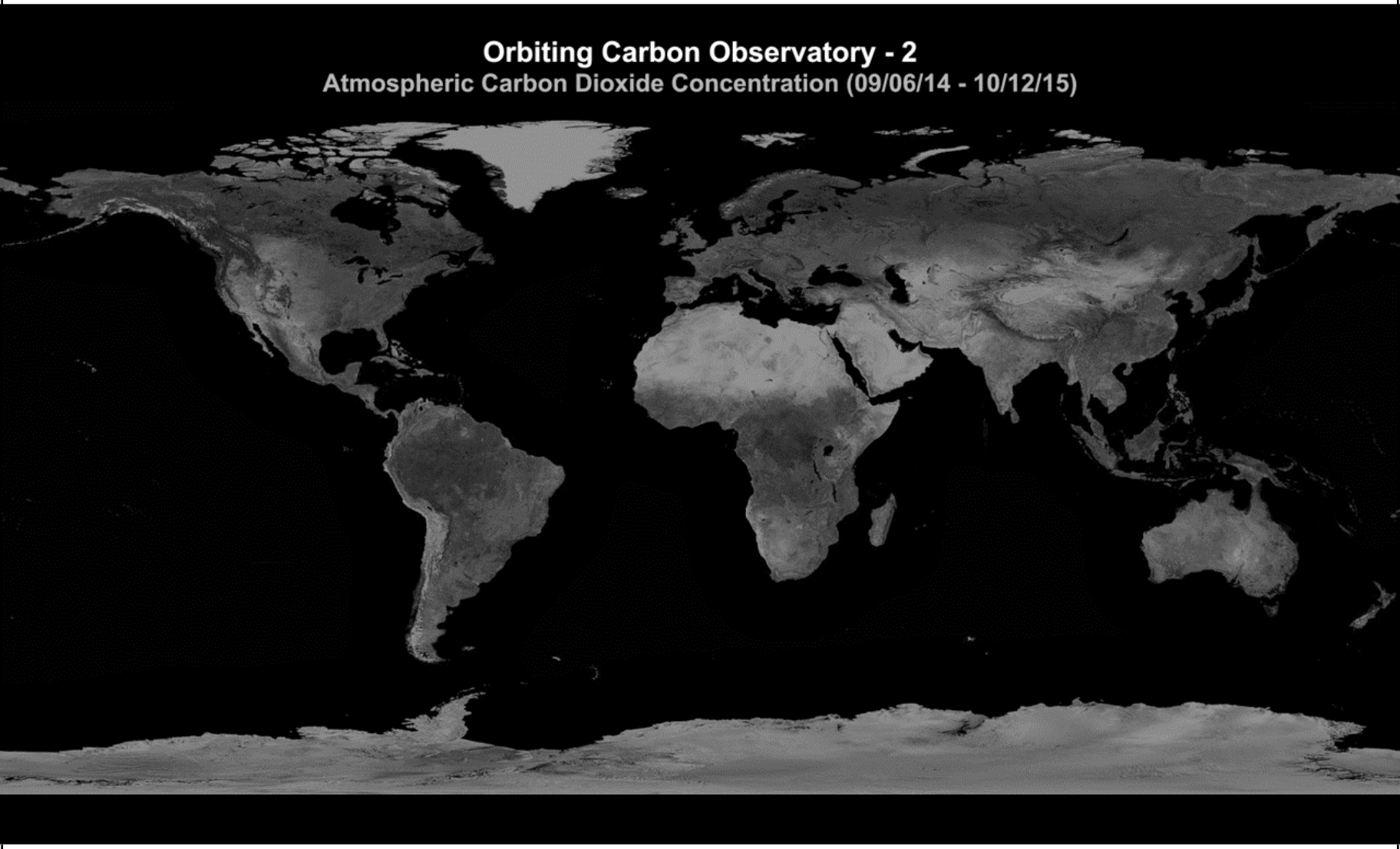
O_2 A-Band

CO_2 1.61 μm Band

CO_2 2.06 μm Band

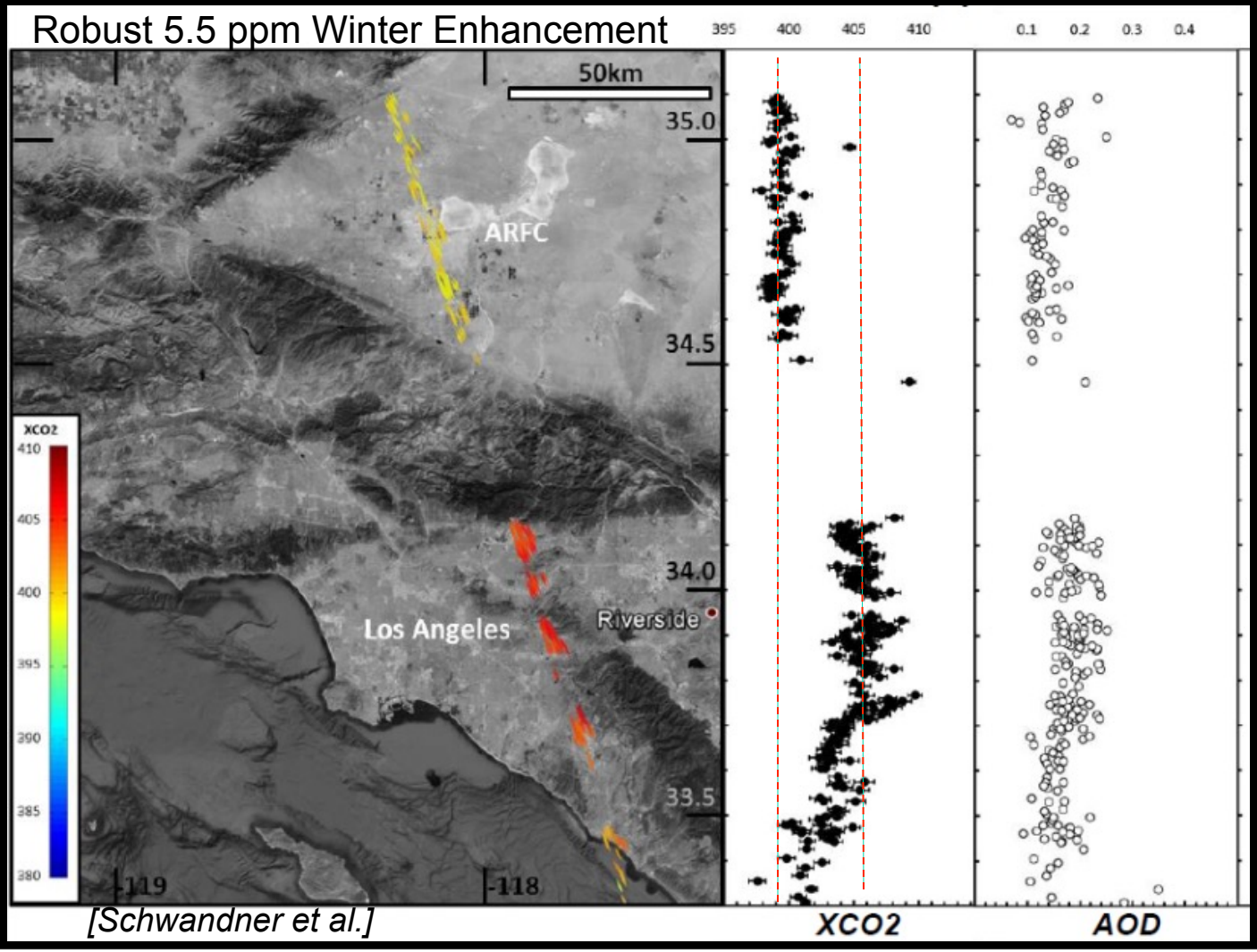
Each 1/3 of a second frame includes 8 spatial footprints with 1,016 wavelengths sampled in the O_2 A-band and Weak and Strong CO_2 bands yielding almost 1 million soundings each day

A Quick Look at the First 13 Months of Operations



Small-Scale Emission Structures

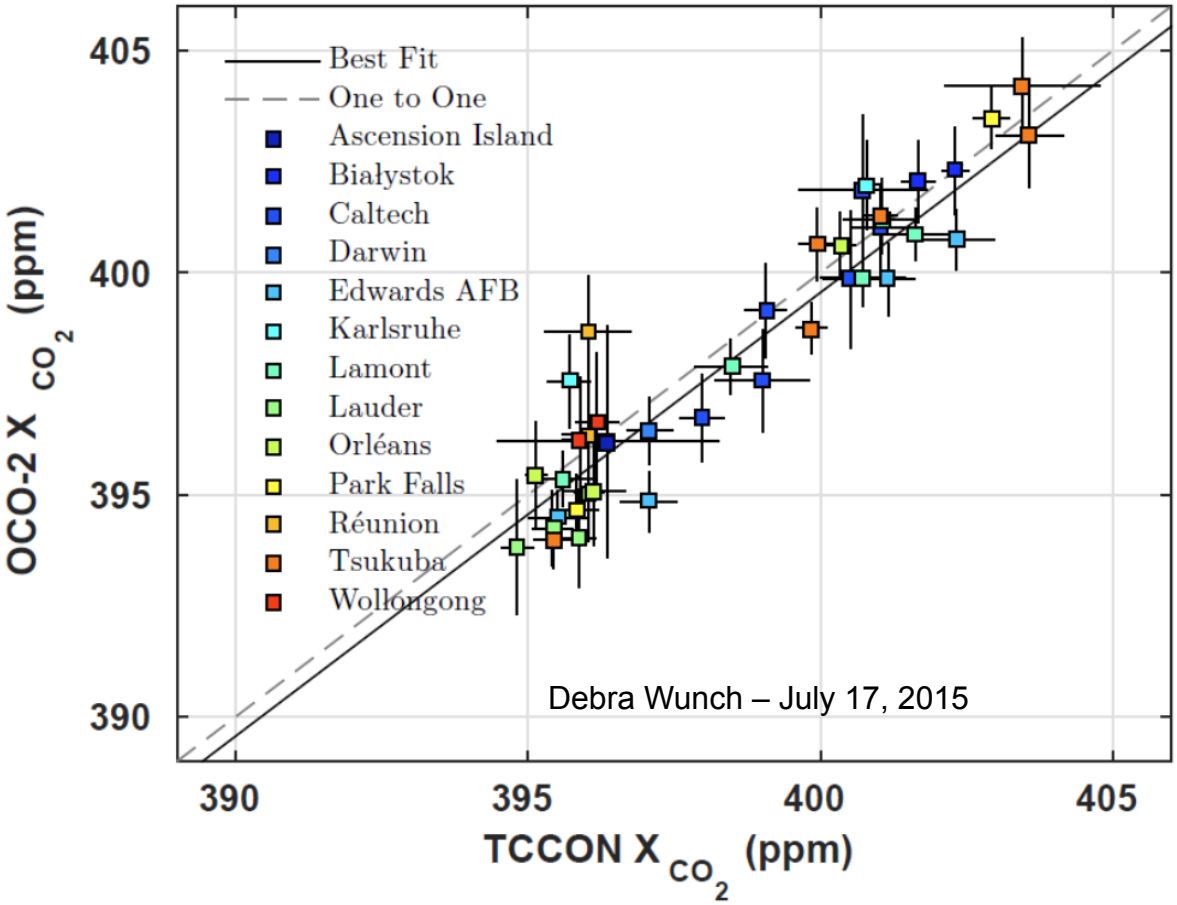
2015/01/13 Glint orbit 2848 over Los Angeles and Antelope Valley



[Schwandner et al.]

Target Observations

Comparison of TCCON and OCO-2 X_{CO2}



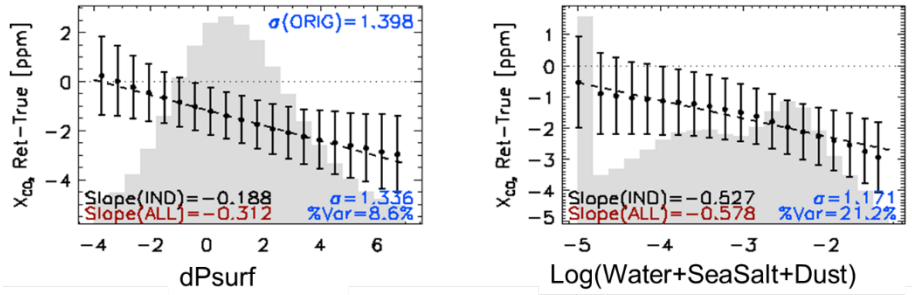
Comparisons with Total Carbon Column Observing Network (TCCON) stations are being used to identify and correct biases in target observations.

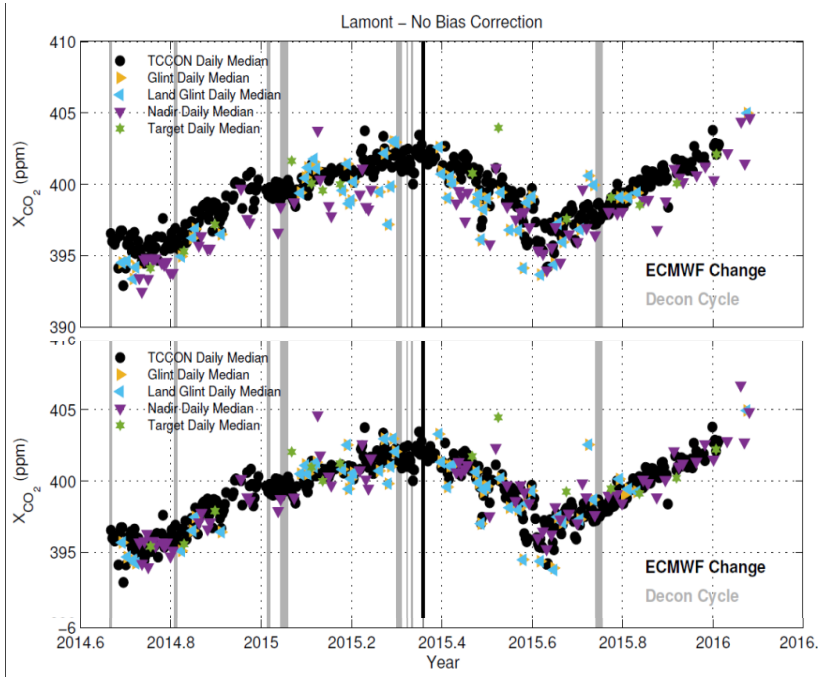
After applying a preliminary bias correction, differences are approaching 1 ppm.

Bias Assessment

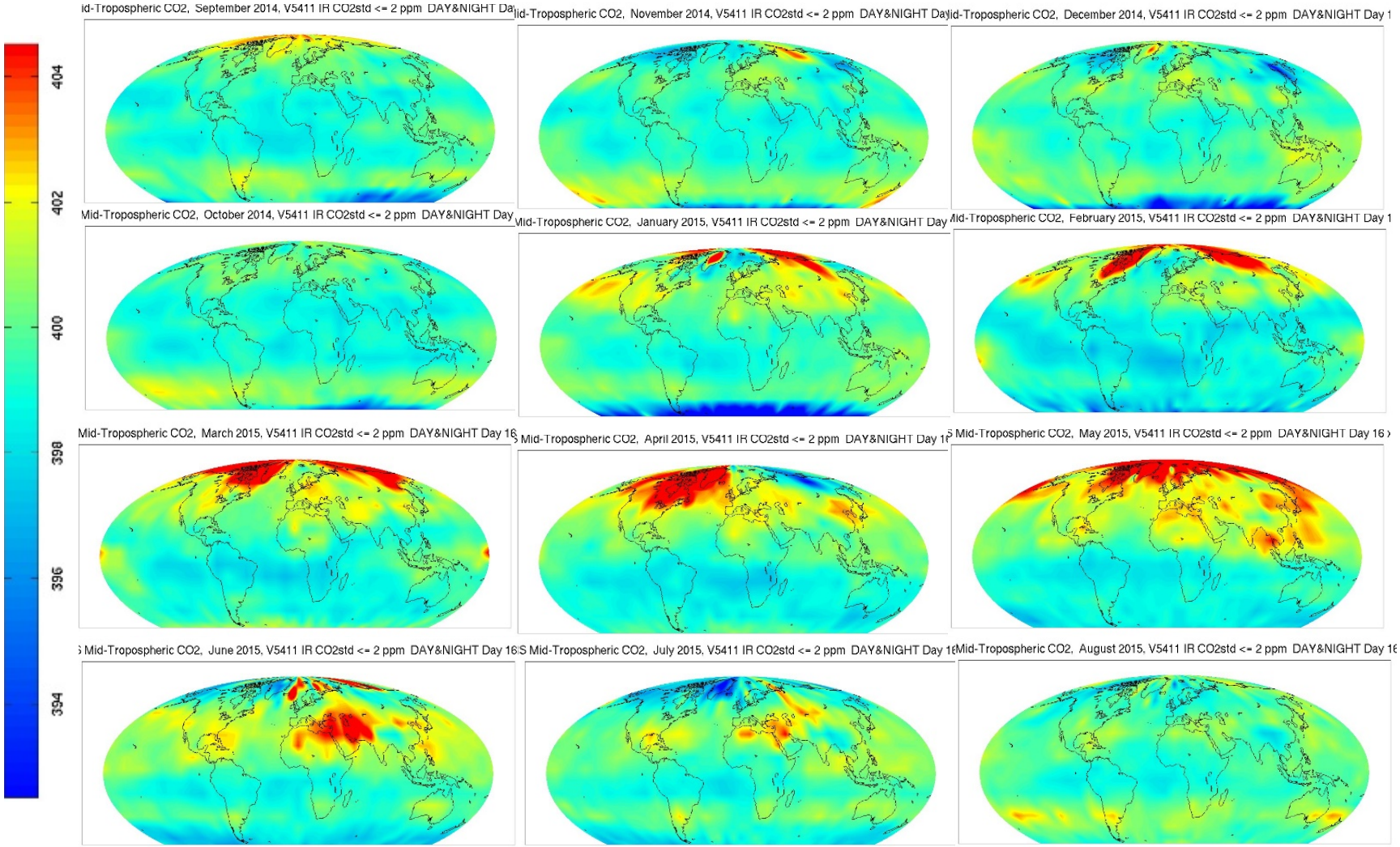
- Target observations provide a large comparison data set (>1000 soundings for each target).

- Bias is evident
  - Errors in the retrieved surface pressure produce compensating errors is X_{CO2}
  - Other key drivers of bias are low clouds (indicated by CO_2 or H_2O ratios) high aerosols AOD and high surface albedos

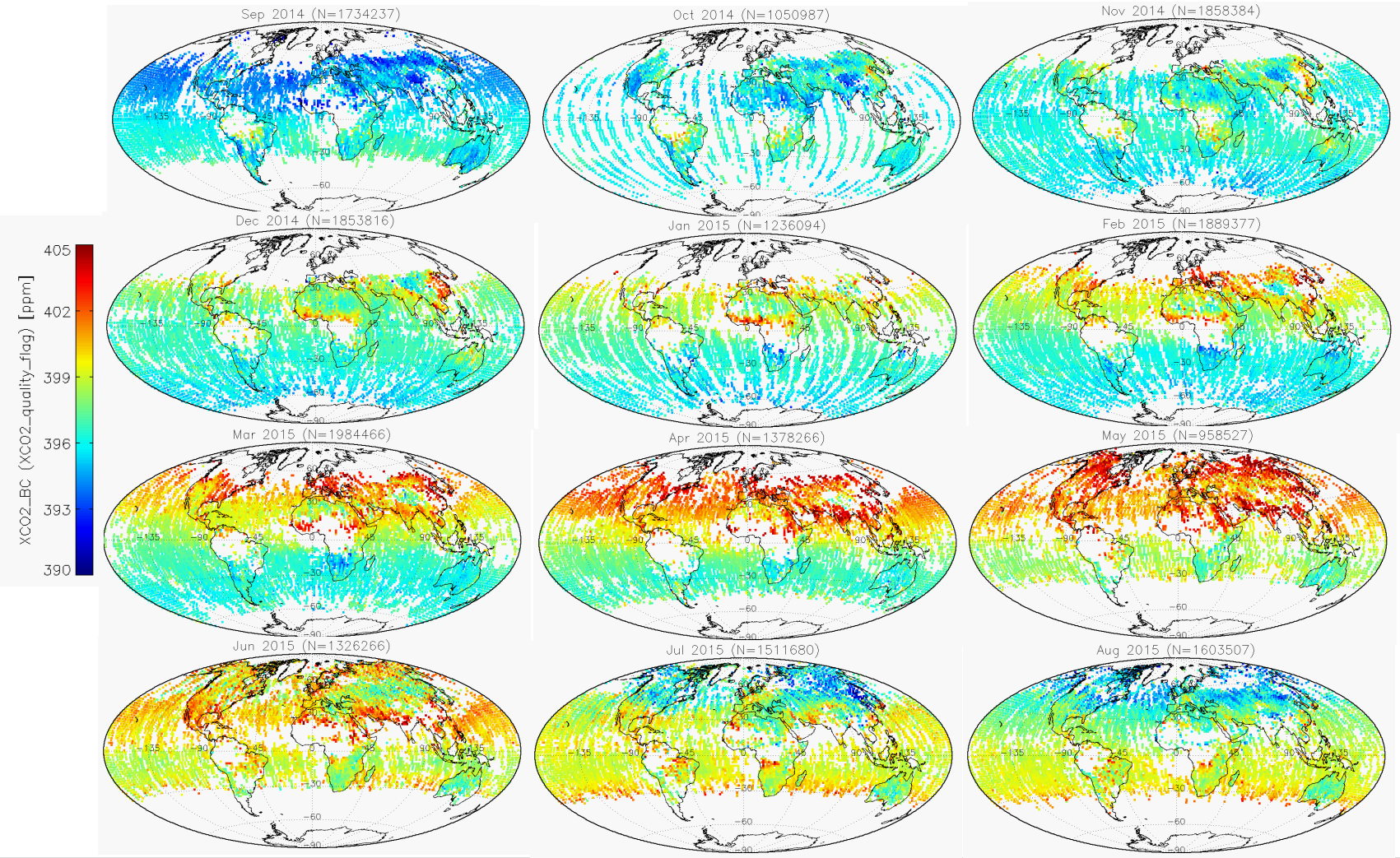




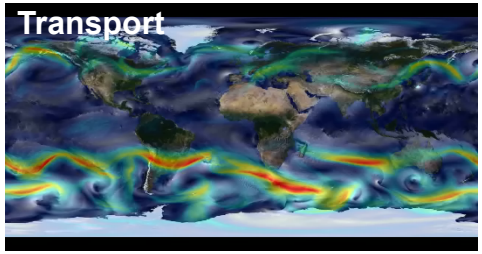
AIRS v5 CO2


404
402
400
398
396
394
Mid-Tropospheric CO2, September 2014, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day
Mid-Tropospheric CO2, November 2014, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day
Mid-Tropospheric CO2, December 2014, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 1
Mid-Tropospheric CO2, October 2014, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day
Mid-Tropospheric CO2, January 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day
Mid-Tropospheric CO2, February 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 1
Mid-Tropospheric CO2, March 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 16
Mid-Tropospheric CO2, April 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 16
Mid-Tropospheric CO2, May 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 16
Mid-Tropospheric CO2, June 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 16
Mid-Tropospheric CO2, July 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 16
Mid-Tropospheric CO2, August 2015, V5411 IR CO2std <= 2 ppm DAY&NIGHT Day 16

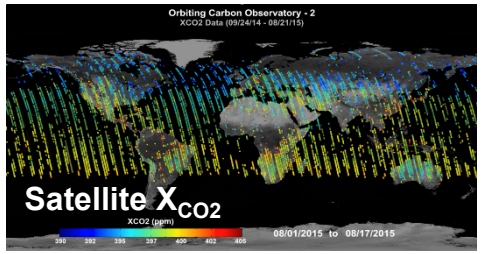
OCO-2 V7r


Sep 2014 (N=1734237)
Oct 2014 (N=1050987)
Nov 2014 (N=1858384)
Dec 2014 (N=1853816)
Jan 2015 (N=1236094)
Feb 2015 (N=1889377)
Mar 2015 (N=1984466)
Apr 2015 (N=1378266)
May 2015 (N=958527)
Jun 2015 (N=1326266)
Jul 2015 (N=1511680)
Aug 2015 (N=1603507)
XCO2_BC (XCO2_quality_flag) [ppm]
405
402
399
396
393
390

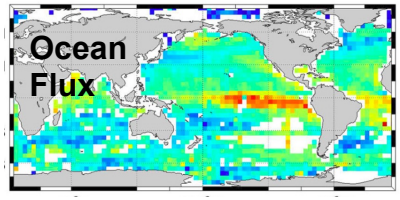
“Top-Down” Flux Inversion Estimates

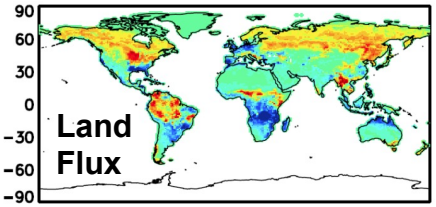


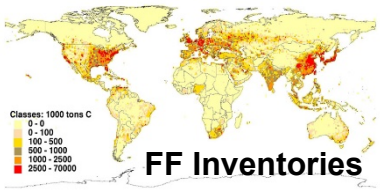
In situ CO_2



Prior Fluxes



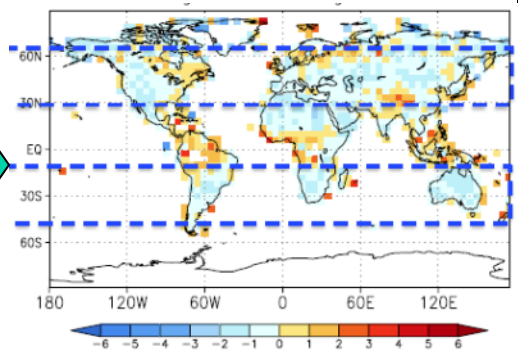




Flux Inversion Model

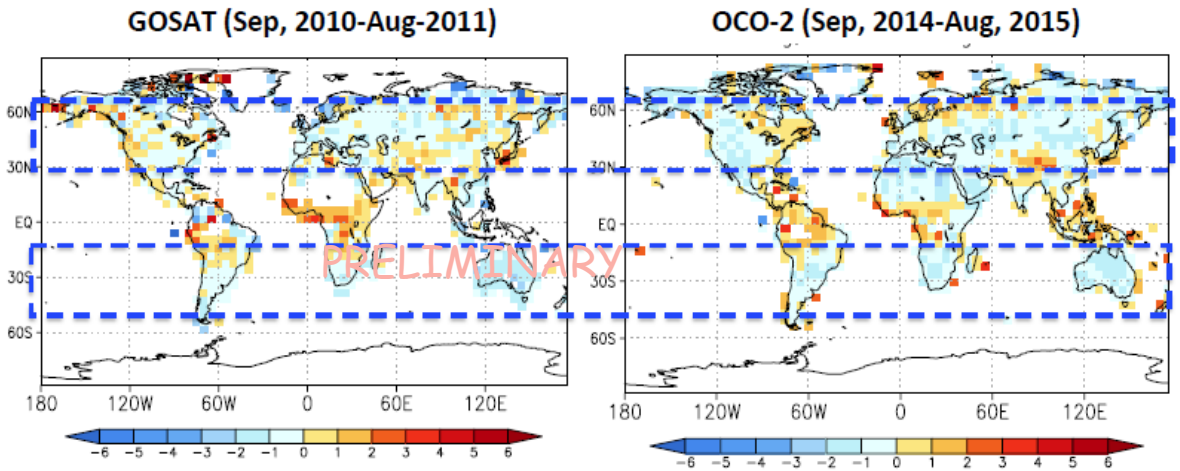
$$\frac{\partial C}{\partial t} = E - kC$$

Optimizer

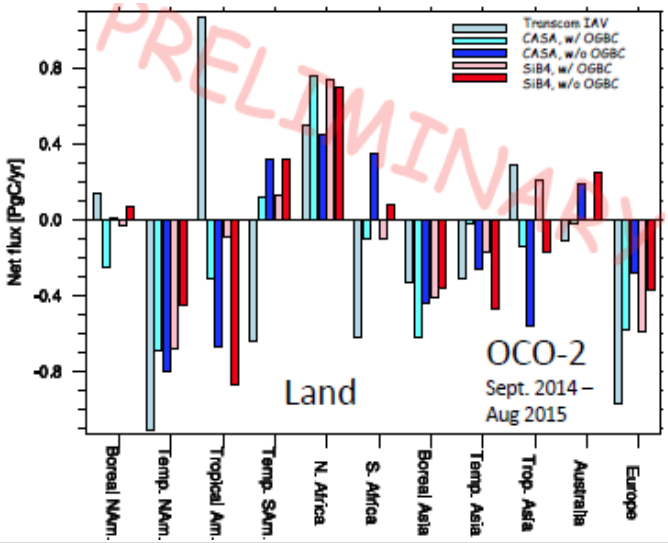


Optimized Fluxes

Preliminary CO_2 Flux Inversion Results

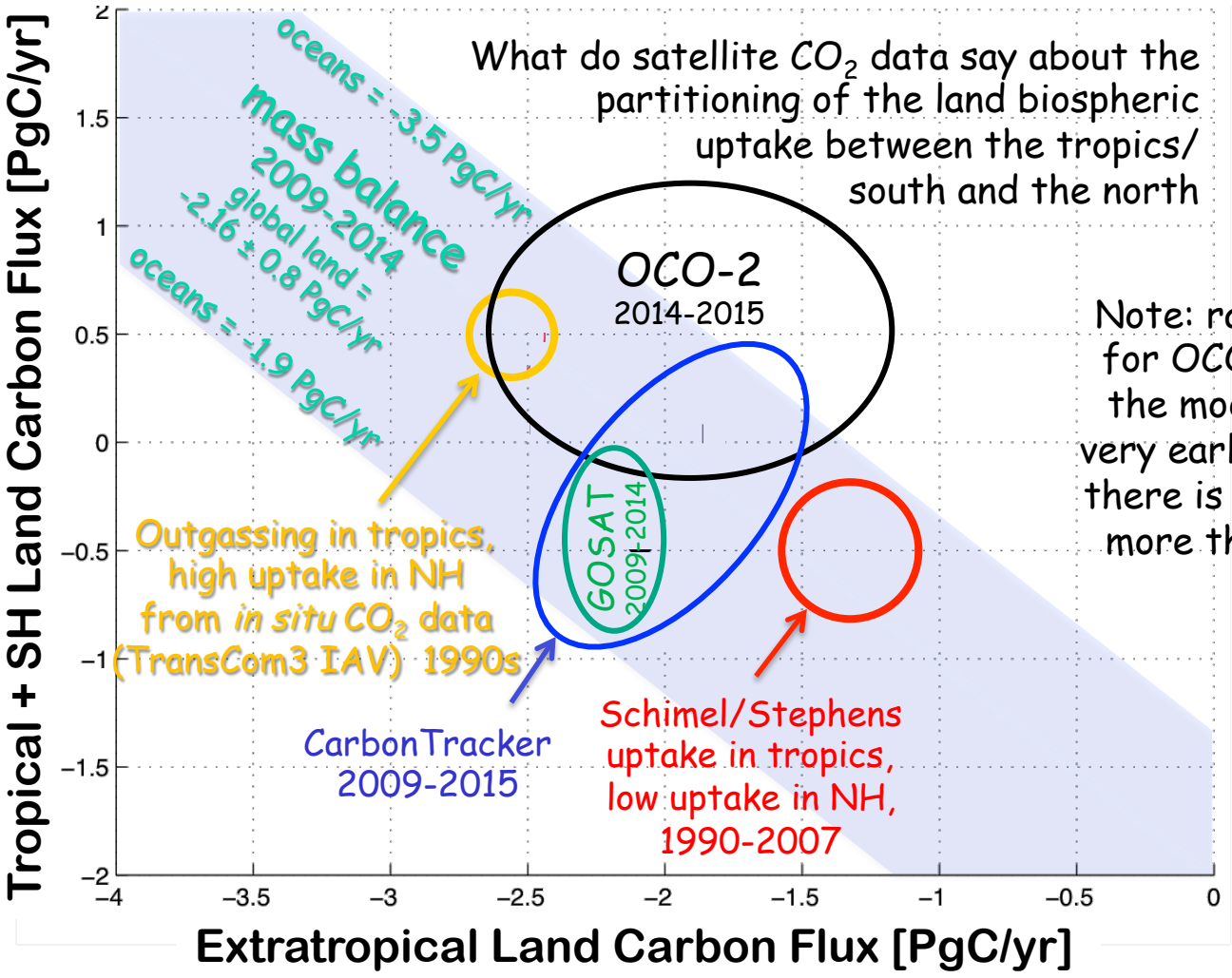


GOSAT & OCO-2 inversions indicate larger sources in tropics and larger sinks at higher latitudes [J. Liu et al.]

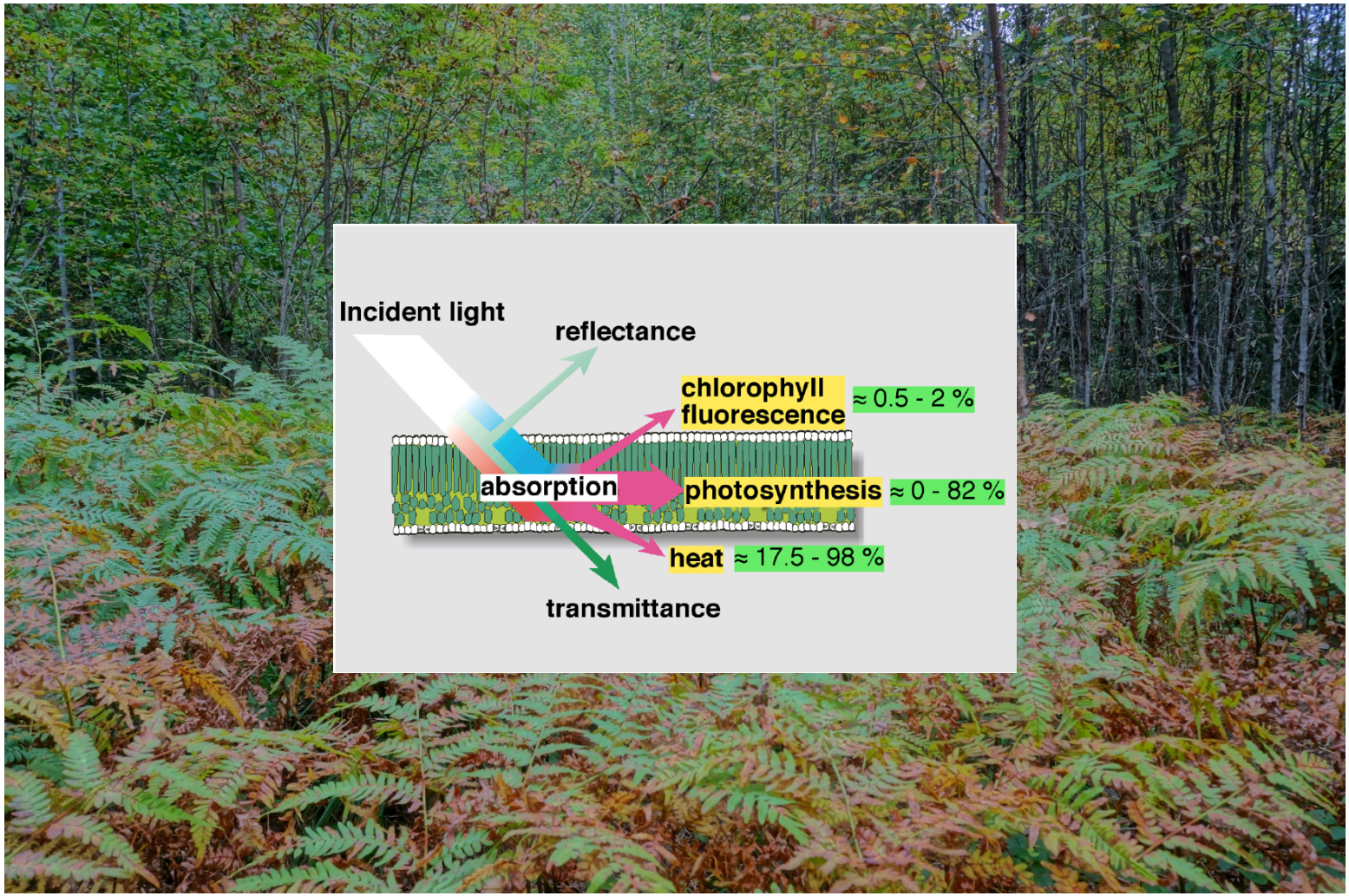


CO_2 flux amplitude depends on bias correction applied to OCO-2 data [D. Baker]

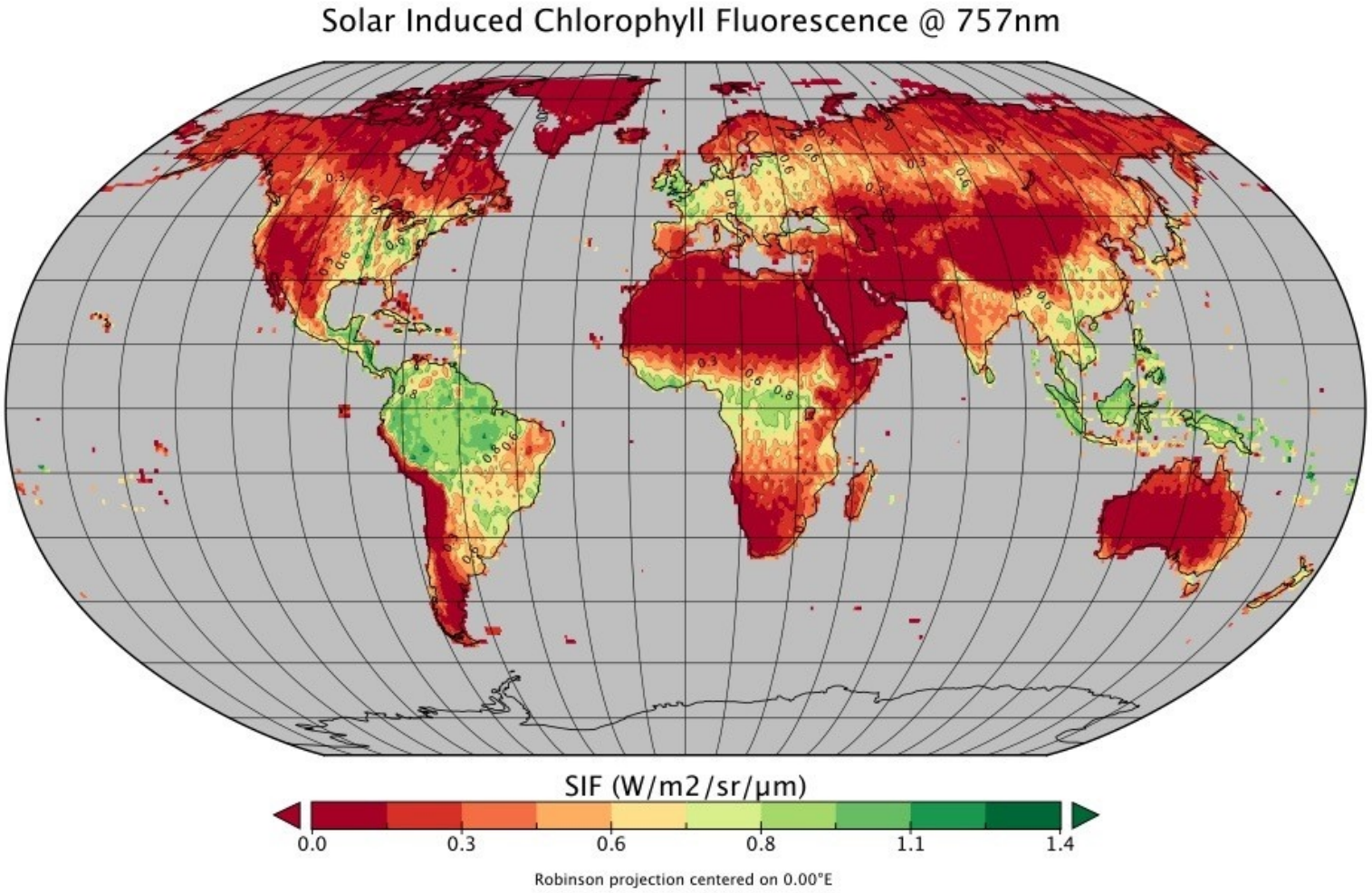
Partitioning of Land Biospheric Uptake



Solar-Induced Chlorophyll Fluorescence (SIF)



OCO-2 Observations of SIF



Summary

- OCO-2 was successfully launched on 2 July 2014, and began routine operations on 6 September 2014
  - Now returning about 1 million measurements each day over the sunlit hemisphere
  - Over 10% of these measurements are sufficiently cloud free to yield full-column estimates of X_{CO2}
- Over one year of data has been delivered to the Goddard Earth Sciences Data and Information Services Center (GES-DISC) for distribution to the science community
  - All data back to September 6 2014 have been reprocessed

http://disc.sci.gsfc.nasa.gov/OCO-2

- This product is now being used by the world's carbon cycle science community to identify and quantify the CO_2 sources and sinks on regional scales over the globe

Thank You for Your Attention

Questions?